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AUTOMATIC SOLAR PHOTOVOLTAIC BATTERY MONITORING AND THEFT CONTROLSYSTEM

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ABSTRACT

Being able to monitor the SPV battery remotely then it makes important to reducing time and cost associated with site visits. This is obviously especially important for an-off-grid system, which is often in even harder to reach the remote area. Solar Photovoltaic stand-alone power sources are mainly used for outdoor lightings, such as garden lighting, street lighting etc. Batteries are invariably used to store the solar energy during its availability. Solar photovoltaic pannels and the batteries are often located in open fields and remote areas, due to these two problems associated with it. Firstly, the batteries are more vulnerable to theft. Secondly, the monitoring of dry run or discharge of batteries and maintenance becomes difficult and expensive.

This paper will explain the method to control the battery theft and maintenance of the batteries used in SPV systems. Objectives of this system are i) to sense if the battery is lifted from its place and alert the authorized person by call and message ii) battery temperature monitoring and display of the same in the LCD. iii) And it also indicates the under and over voltage of the system. The proposed monitoring and security system has sensing unit and the main unit. Sensing unit consists of an accelerometer to sense the displacement of the battery from its place and a unit to monitor the temperature of the battery. Temperature is measured using LM35 temperature sensor. The main unit includes LCD, GSM Module, Buzzer and two microcontrollers. Microcontroller (P89V51RD2BN) is interfaced with GSM module, Buzzer and LCD. Microcontroller (AT89C2051) receives the signals from the temperature sensing unit and theft sensing unit, convert the parallel data to serial data and sends the serial data to the main unit through the Zig-Bee RFM75 transceiver. The LCD is used to display the status of the battery. The GSM module is used to send alert text messages in case of temperature rise of the battery. Further, a phone call is made to the authorized person as well as buzzer beeps to alert battery theft.

KEYWORDS: Zig-Bee RFM75 Transceiver, LM7805 Regulator, GSM Module & Microcontroller

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Original Article

INTRODUCTION

As the energy demand around the world increase, the need for alternative energy sources increase. Therefore, there is a requirement to exploit new and renewable sources of energy (e.g. solar energy, wind, geothermal ….etc.). Renewable energy is natural energy which does not have a limit. Solar energy is a renewable energy source that is environmentally friendly and unexhausted. Unlike other fossil fuels, solar energy is available everywhere on the earth and this source of energy is free. Stand–Alone SPV system with battery backup can supply power to electrical loads with availability about 100% during all the operating environmental conditions. SPV systems are generally designed so that there is a deficit in energy in winter, but a surplus in summer. This deficit and

surplus can lead respectively to over discharging and overcharging of the batteries, which damage the batteries, shortening their life and increasing maintenance. Batteries are generally the most practical form of energy storage due to their size to weight ratio and their cost. Hence batteries are used to store the renewable energy in its availability. Batteries are what make renewable energy practical. So there is a need to provide monitoring and security system for batteries.

Solar Photovoltaic stand-alone power sources are popularly used for outdoor lighting, viz, garden lighting, street lighting etc. Batteries are invariably used to store the solar energy during its availability. Solar power energy sources and the batteries are often located in open fields and remote areas. Two problems are associated with said applications. Firstly, the batteries are more defenceless to theft. Secondly, the checking of dry run or discharge of batteries and maintenance becomes difficult and costly. To address these problems there is a need to design and develop an economically viable automated security system

The proposed system protects the battery used in SPV systems from theft and maintains its performance. Objectives of this proposed system are i) to sense if the battery is lifted from its place and alert the authorized person by call ii) to observe temperature discharge and dry run and display of the same in the LCD. iii) Monitor the under and over voltage of the batter used in SPV system. The proposed monitoring and security system consisting of sensing and the main unit. Sensing unit consists of an accelerometer to sense the displacement of the battery from its place and a unit to monitor the temperature of the battery. Temperature is measured using LM35 temperature sensor. The main unit includes LCD, GSM Module, Buzzer and two microcontrollers. Microcontroller (P89V51RD2BN) is interfaced with GSM module, Buzzer and LCD. Microcontroller (AT89C2051) receives the signals from the temperature sensing unit and theft sensing unit, convert the parallel data to serial data and sends the serial data to the main unit through ZigBee transceiver. The LCD is used to display the status of the battery. The GSM module is used to send alert text messages in case of temperature rise of the battery. Further, a phone call is made to the authorized person as well as buzzer beeps to alert battery theft.

Benefits

- This system will sense if the battery is lifted from its place–either by displacement sensor or by the load cell. This includes design of a circuit and developing software to

  (a) Raise alarm siren

  (b) Send alert messages to the user's cell phones

  (c) Call to authorized person

- This system will monitor the battery temperature and check whether the temperature of the battery is within its specified limits.
- And monitor the battery voltage and check whether the voltage of the battery is within its specified limits

BLOCK DIAGRAM OF PROPOSED SYSTEM

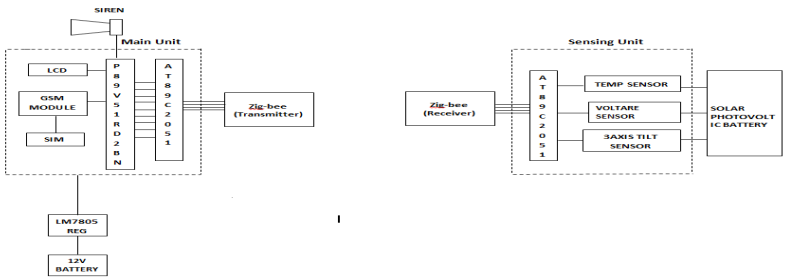

Figure 1: Block Diagram of Proposed System

Main Components

- **Sensor Unit**

Sensing unit is attached to the one side of the battery. It includes temperature sensing unit, voltage monitoring unit and theft sensing unit.

- **Theft Sensing Unit**

Theft sensing unit with the help of accelerometer is used to sense if the battery is lifted from its place. When a person lifts the battery from its place, accelerometer axes are changed from the reference axis, and the theft sensing unit sends the signals to the microcontroller to take further actions.

- **Temperature Sensing Unit**

Temperature sensing unit is used to measure the temperature of the battery. When the temperature of the battery exceeds a specified value, this unit will send a signal to the microcontroller to avoid adry run.

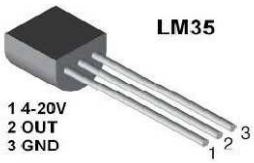

Figure 2: Lm35 Temperature Sensor

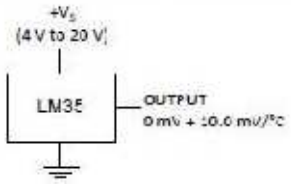

Figure 3: Symbolic Diagram of LM35

- **Zig-Bee**

The Zig-Bee RFM75 USB device is a transceiver which has a frequency band ISM operating at 2400 to 2483.5 megahertz available in the worldwide. The RFM75 is used in the applications where the consumption of the power is low. It transmits in burst mode and the air data rate is up to 2Mbps.

RFM75 USB Zig-Bee operates as a transmitter or operates as a receiver when it is in TDD mode. The serial data

to transmit and to receive with baud rate adjustable at RS232 level is of 9600/4800/38400/19200 bps for interfacing directly to computer port USB or similar devices.

RFM75 can work with another model like sensor embedded type with 2.4GHz, and it can work at a range of 30meter. This can be used where there is the two-way transmission of the data is to be wireless. The transmission distance is farther and it has high rated data. It has a transparent user interfacing and the protocol to communicate is self-controlled. To the present design, the module is embedded to communicate wireless and is easy to setup. If the transmitter and receiver are to communicate with each other, it has to be programmed with the RF channel frequency with the same value.

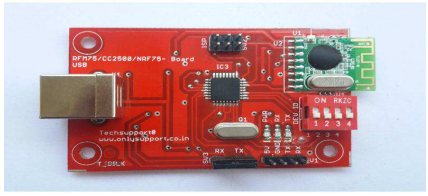

Figure 4:Zig-Bee Usb Rfm75/Cc2500/Nrf75-Board

RFM75 PIN ASSIGNMENTS

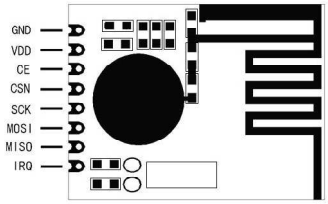

Figure 5:Zig-Bee Rfm75 Pin Assignment

The Applications of RFM75 are as Follows

- Peripherals of PC like keyboard, mouse, joystick which are wireless uses RFM75
- It is used in consumer electronics like VCR, remote, TV, DVD or CD etc.
- It is used in wireless gamepads
- It is used in remote controls
- It is used for personal health care like patient monitoring and fitness monitoring
- It is used in the industrial control like asset management, process control, energy management, environment etc.
- It is used in wireless audio
- It is used in the light control of residential or commercial like lighting control, lawn and garden irrigation, security, HVAC etc.
- It is used in the Toys
- It is used in building automation like security, access control, AMR, HVAC, lighting control etc.
- It is used automation of home.

The RFM75 Zig-Bee has following Features

- The band operation ISM is 2400 t 2483.5 MHz
- The air data rate supporting are 250Kbps, 1Mbps and 2Mbps
- It is programmable output power
- For the 16Mhz crystal tolerate is ±60ppm
- Power supply is 1.9V to 3.6V
- Packet processing is automatic
- The payload length which is variable is from 1 to 32 bytes
- The SPI 4 pin interfaces clock rate with maximum 8 MHz
- It has QFN package with 20pin 4*4mm.

Table 1: Zig-Bee Rfm75 Pin Function

Name	Pin Function	Description
GND	Ground	Ground (0 V)
VDD	Power	Power Supply (1.9 V to 3.6 V DC)
CE	Digital Input	Chip Enable Activates RX or TX mode
CSN	Digital Input	SPI Chip Select, Active low
SCK	Digital Input	SPI Clock
MOSI	Digital Input	SPI Slave Data Input
MISO	Digital Output	SPI Slave Data Output with tri-state option
IRQ	Digital Output	Maskable interrupt pin, Active low

- **Microcontroller (AT89C2051)**

This is a 20 pin microcontroller which receives the signals from the temperature sensing unit, voltage monitoring unit and theft sensing unit and converts the parallel data to serial data and sends the serial data to the main unit through ZigBee transceiver.

Figure 6: AT89C2051 Microcontroller

- **Main Unit**

The main unit consists of two microcontrollers, one is of 40 pins and another one is of 20 pins, GSM module, Buzzer, Liquid Crystal display (LCD).

- **Microcontroller (AT89C2051)**

The 20-pin microcontroller receives the data from another 20 pin microcontroller which is in sensing unit and converts the serial data to parallel data.

- **Microcontroller (P89V51RD2BN)**

This is the 40 pin microcontroller used, in the main controlling unit. It is interfaced with GSM module, Buzzer and LCD.

- **Liquid Crystal Display (LCD)**

It receives the signals from the main controlling unit and continuously displays the status of the battery i.e. alert, over voltage, under voltage and temperature.

- **Global System for Mobile Communication (GSM) Module**

It receives the signals from the main controlling unit. GSM is used to send the alert message to the concerned authorized person in case of temperature rise of the battery. It is also used to call a concerned authorized person in case of stealing of battery.

Figure 7: Gsm Modem

- **Buzzer**

The buzzer is used to alert the people who are around the energy park. When a battery is lifted from its place, buzzer starts beeping and continues until the supply is switched off.

- **LM7805 Regulator**

A DC power supply system, which maintains constant voltage irrespective of fluctuations in the main supply or variation in the load, is known as regulated Power supply. The 7805 IC referred to the fixed positive voltage regulator, which provides fixed voltage 5 volts.

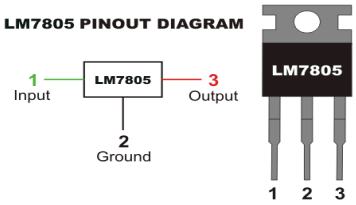

Figure 8: Pin Diagram of LM7805 Voltage Regulator

- **Temperature Sensing Circuit (LM35)**

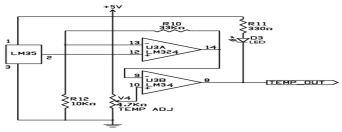

Figure 9: Temperature Sensing Circuit Diagram

Figure 9 shows temperature sensing circuit diagram. The LM35 is a precision integrated-circuit temperature

sensor, whose output voltage is linearly proportional to the Celsius temperature. The LM35 temperature sensor produces an output voltage of 10mV for every 1^0C rise in temperature. The maximum temperature limit for the battery is 55^0C. At this temperature, the sensor will produce 550mV which is very small to compare with reference value. The Op-amp U3A amplifies this output signal with a multiplication factor of 4.3 (Gain = 1+R10/R12) so for a temperature of 55^0C, the sensor will produce an output voltage of 550mV which is further amplified by the Op-amp U3A 4.3 times which will be 2.37V approximately. This level is compared by U3B against a preset level decided by potentiometer V4 and if the input level is greater than the preset level the comparator will output a logic low level on the TEMP_OUT which is further detected by the micro-controller for raising alert to take safety measures.

Theft Sensing Circuit(ADXL335)

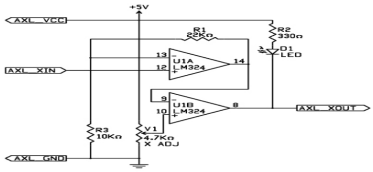

Figure 10a: Theft Sensing Circuit (AXL X-Axis)

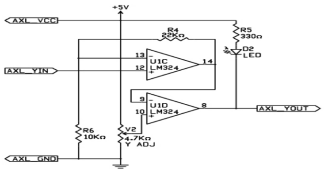

Figure 10b: Theft Sensing Circuit (AXL Y-Axis)

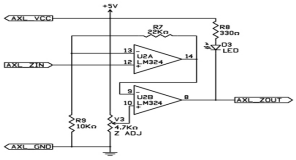

Figure 10c: Theft Sensing Circuit (AXL Z-Axis)

The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The theft sensing circuit for X-axis is illustrated in the Fig. 3.2a. When a battery is lifted from its place, the AXL_XIN produces an output voltage of 0.8 V, which is very small to compare with reference value. The Op-amp U1A amplifies this output voltage with a multiplication factor of 3.2 (Gain = 1+R1/R3) which will be 2.56 V. This voltage is compared by U1B against a preset level decided by potentiometer V1 and if the input level is greater than the preset level the comparator will output a logic low level on the AXL_XOUT which is further detected by the micro-controller to send alert messages and calls the concerned authorized person through GSM.

Interfacing of Sensing Unit

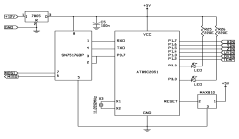

Figure 11: Interfacing of Sensing unit with Microcontroller

Figure 11 Shows Interfacing of Sensing unit with a microcontroller. It mainly Consists of MAX810, AT89C2051 and SN75176BP

MAX810

It is single function microcontroller reset, used to monitor the supply voltages in the microcontroller. It provides a reset signal to microcontroller during power up and power down and brownout conditions. The reset signal is asserted when the supply voltage drops below the preset threshold, and the signal is released a set time after the supply voltage has risen above the preset threshold.

AT89C2051

It is a 20 pin microcontroller. It is used to scan the output signals of the sensing units such as theft alert, temperature rise, under voltage and over voltage. These signals are given to port 1 as input. The status of the port 1 is sent to SN75176BP through TxD pin.

Interfacing of GSM Module, LCD and Buzzer

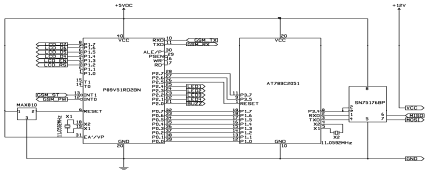

Figure 12: Interfacing of GSM Module, LCD and Buzzer with Microcontrollers

Figure 12 shows interfacing of GSM module, LCD and Buzzer with microcontrollers. It mainly consists of AT89C2051 and P89V51RD2BN microcontrollers.

AT89C2051

The AT89C2051 is a 20 pin, low voltage high-performance CMOS 8-bit microcomputer with 2k bytes of flash programmable and erasable read only memory (PEROM). It is used to receive the serial data from 4-core cable and converts into parallel data. The parallel data is sent to the P8V51RD2BN microcontroller.

P89V51RD2BN

The P89V51RD2BN is a 40 pin microcontroller, which is a main controlling unit. It receives the signal from the AT89C2051 microcontroller and sends the signals to GSM module, LCD and Buzzer unit. The LCD displays the status of the battery and GSM sends alert text messages in case of under voltage, over voltage and temperature rise of the battery. Further, a phone call is made to the authorized person as well as the buzzer beeps to alert battery theft.

Figure 13: P89V51RD2BN Microcontroller

FLOW CHART

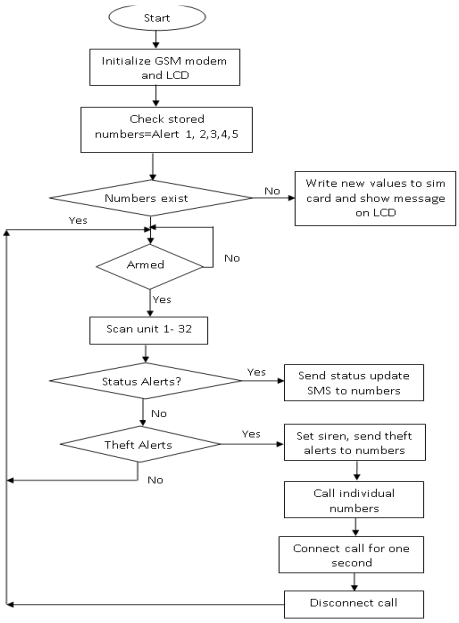

Figure 14: Flowchart for the main Unit

OBSERVATION

Observation can be been carried out by varying the i) Position ii) Temperature iii) voltage charging and discharging andcorresponding output is observed in LCD. During the normal condition of the battery, all the bits such as A, U, O and T are set to 0. In case of theft (A) and temperature rise (T) of the battery, the respective alert bits are set to 1. During cable disconnection, all bits are set to 1. For under voltage (U) bit is set to 1and for over voltage (O) bit is set to 1. the status of the battery displayed on LCD for different conditions is given below.

Normal Condition

A	U	O	T
0	0	0	0

Over Voltage

A	U	O	T
0	0	1	0

Temperature Rise

A	U	O	T
0	0	0	1

Theft

A	U	O	T
1	0	0	0

Cable Disconnection

A	U	O	T
1	0	0	1

Under Voltage

A	U	O	T
0	1	0	0

ADVANTAGES AND APPLICATIONS

Advantages

- Provides safety and security from theft.
- Saves money-providers remote securities thereby avoiding salaried staff.
- Better battery performance-battery maintenance can be taken up in time due to timely alertness from the project.
- Energy conservation is promoted.

Applications

- Uninterruptible power supplies.
- Street Lighting.
- Automotive and Traction applications.
- Standby/Back-up/Emergency power for electrical installations.

CONCLUSIONS

From the above discussions, it can be observed that an accelerometer is used as a sensor to detect displacement of the battery due to theft. The LM35 temperature sensor monitors battery temperature. This proposed system meets all the benefits such are;

- A sensor circuit to sense if the battery is lifted from its place–either by displacement sensor or by the load cell. This system will perform the following action when battery is lifted from its place

(a) Raise alarm siren

(b) Send alert messages to the user's cell phones

(c) Call to authorized person

- This system will monitor the battery temperature and check whether the temperature of the battery is within its specified limits.
- And monitor the voltage and check whether the voltage of the battery is within its specified limits.

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